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Comparison Of Analytical Methods For Calculation Of Wind Loads

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REVISION A

COMPARISON OF ANALYTICAL METHODS FOR CALCULATION OF WIND LOADS

This Revision Supersedes All Previous Editions of This Manual

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ABSTRACT

The following analysis is a comparison of analytical methods for the calculation of wind load pressures. The analytical methods specified in ASCE Paper No. 3269, ANSI A58.1-1982, the Standard Building Code, and the Uniform Building Code were analyzed using various hurricane speeds to determine the differences in the calculated results. The winds used for the analysis ranged from 100 mph to 125 mph and applied inland from the shoreline of a large open body of water (i.e., an enormous lake or the ocean) a distance of 1500 feet or ten times the height of the building or structure considered. For a building or structure less than or equal to 250 feet in height acted upon by a wind greater than or equal to 115 mph, it was determined that the method specified in ANSI A58.1-1982 calculates a larger wind load pressure than the other methods. For a building or structure between 250 feet and 500 feet tall acted upon by a wind ranging from 100 mph to 110 mph, there is no clear choice of which method to use; for these cases, factors that must be considered are the steady-state or peak wind velocity, the geographic location, the distance from a large open body of water, and the expected design life and its risk factor.

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ABBREVIATIONS AND ACRONYMS

ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
CA	California
e.g.	for example
ft	foot
ft^2	square foot
FL	Florida
i.e.	that is
KSC	John F. Kennedy Space Center
lb/ft^2	pound per square foot
lb_f	pound force
mph	mile per hour
NASA	National Aeronautics and Space Administration
no.	number
NY	New York
psf	pounds per square foot
SF	shape factor
STD	standard
%	percent

SYMBOLS AND NOTATION

a	Coefficient alpha that depends on the exposure type
A_f	Projected area normal to the wind velocity except when is given for the surface area (ft^2)
C_D	Shape coefficient
C_f	Force coefficient
C_p	External pressure coefficient
D_o	Surface drag coefficient
F_z	Design force at a specific height, Z (lb_f)
G_h	Gust response factor for main-force resisting systems evaluated at height Z=h
G_z	Gust response factor to be used for components and cladding
I	Importance factor
K_z	Velocity pressure exposure coefficient
P_z	Steady-State total wind pressure on primary framing due to constant wind loads (lb/ft^2 or psf)
$P_{z,max}$	Peak total wind pressure on primary framing due to gusting winds (lb/ft^2 or psf)
q_z	Wind velocity pressure at a height, Z (lb/ft^2 or psf)
$q_{z,max}$	Peak wind velocity pressure at a height, Z (lb/ft^2 or psf)
SF	The shape factor is a coefficient that depends on the exterior surface of the building or structure
T_z	Equation variable that depends on a, D_o, and Z
U	Risk of occurance
V_z	Wind velocity at a specific height (mph)

$V_{z,max}$	Peak wind velocity at a specific height (mph)
V_{30}	Wind velocity at a height of 30 feet (mph)
x	A constant which linearly reduces from x=0.3 at V_{30}=60 mph to x=0.143 at V_{30}=130 mph
X_{max}	The constant x mentioned above, which is adjusted for peak winds
Z	Height above the ground (ft)
Z_g	Gradient height above the ground (ft)

1. INTRODUCTION

1.1 PURPOSE

The following analysis is a comparison of analytical methods for calculation of wind load pressures specified in ASCE Paper No. 3269, ANSI A58.1-1982, the Standard Building Code, and the Uniform Building Code. These methods were analyzed for various hurricane wind speeds to determine the differences between their calculated wind load pressures.

1.2 FACILITIES AND EQUIPMENT

The analysis included calculations of wind load pressure for only Category III buildings and structures (as defined in ANSI A58.1-1982; see reference 1 in appendix F) because Category III buildings and structures are more closely identifiable with the space vehicle processing and launch facilities at KSC. The buildings or structures used for calculating wind load pressure had four sides with vertically oriented walls. Only Exposure D winds (as defined in ANSI A58.1-1982) were considered because Exposure D closely approximates the topography and the types of winds experienced at KSC. For a detailed description of the building or structural constraints that were followed see 2.1.

1.3 DEFINITIONS

For the purpose of this report, the following definitions shall apply:

Category III Building or Structure: Buildings or structures designated as essential facilities including, but not limited to, hospitals, fire stations, disaster operations centers, and national defense centers.

Exposure D: Flat, unobstructed areas exposed to wind flowing over large bodies of water. Exposure D applies only from the shoreline a distance of 1500 feet or ten times the height of the building or structure under consideration, whichever is greater.

Ground Wind: Wind that affects facilities and space vehicles during ground operations and immediately after a launch. These winds exist below a height of 500 feet. Ground winds are sometimes referred to as surface winds.

Gust: A sudden increase in the ground wind speed. A gust is frequently expressed as a deviation from a mean wind speed.

Importance Factor: A factor that accounts for the degree of hazard to human life and damage to property.

Peak Wind Speed: The maximum (essentially, instantaneous) wind speed measured during a specified reference period, such as a hour, day, or month, at a given reference height.

Primary Frames and Systems: An assemblage of major structural elements assigned to provide support for secondary members and cladding. Examples of primary frames and systems include rigid and braced frames, space trusses, roof and floor diaphragms, shear walls, and rod-braced frames.

Shape Factor: A coefficient that accounts for the geometry and orientation of the building or structure.

Steady-State or Average Wind Speed: The mean, over a period of approximately 10 minutes, of the ground wind speed measured at a fixed reference height. Steady-State or average wind speed is usually assumed to be constant as, for example, in spectral calculations.

2. ANALYSIS

2.1 PROBLEM STATEMENT

The objective of the analysis is to compare analytical methods for calculation of the steady-state total wind pressure, peak total wind pressure, and wind velocity profiles of ASCE Paper No. 3269, ANSI A58.1-1982, the Standard Building Code, and the Uniform Building Code. The type of structure considered in the analysis is a Category III building that has four sides with vertically oriented walls. The report compared neither thin and wide (e.g., like a billboard) nor tall and slender (e.g., like a smokestack) buildings or structures. Only primary frames and systems are taken into account and only the windward and leeward sides are analyzed. The roof is not included in this report in order to reduce the number of graphs produced. A steady-state Exposure D wind varying from 100 mph to 125 mph in 5-mph increments is used in the analysis, and the elevation above the ground ranges from 30 feet to 500 feet.

2.2 COMPARISON OF ANALYTICAL METHODS

The following subsections present the formulas used in ASCE Paper No. 3269, ANSI A58.1-1982, the Standard Building Code, and the Uniform Building Code.

2.2.1 AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE) PAPER NO. 3269. The method specified in ASCE Paper No. 3269 has been used in KSC-STD-Z-0004 to calculate wind loads on John F. Kennedy Space Center (KSC) facilities since the early 1960's. The following three subsections present formulas for the steady-state total wind pressure, peak total wind pressure, and steady-state wind velocity profile for ASCE Paper No. 3269, conforming to the criteria of 2.1 of this report (see references 2, 3, and 4 in appendix F).

2.2.1.1 Steady-State Total Wind Pressure, P_z. This subsection presents the formulas for the steady-state total wind pressure. Formula (6) is the complete formula for the steady-state total wind pressure.

$$P_z = q_z C_D \quad \text{(psf)} \tag{1}$$

$$q_z = 0.002558 V_z^2 \quad \text{(psf)} \tag{2}$$

$$V_z = V_{30}(Z/30)^x \quad \text{(mph)} \tag{3}$$

x linearly reduces from:

$x = 0.3$ at $V_{30}=60$ mph to $x=0.143$ at $V_{30}=130$ mph

$$x = 0.3-(0.3-0.143)[(V_z-60)/(130-60)]$$

$$x = 0.3-0.157[(V_z-60)/70] \tag{4}$$

The shape coefficient, C_D, represents the summation of the pressure contributions from the windward and leeward sides.

$$C_D = 1.3 \tag{5}$$

Substitute (2), (3), (4), and (5) into (1)

$$P_z = 0.002558[V_{30}(Z/30)^{(0.3-0.157[(Vz-60)/70])}]^2(1.3) \quad \text{(psf)} \tag{6}$$

2.2.1.2 Peak Total Wind Pressure, $P_{z,max}$. This subsection presents the formulas for the peak total wind pressure. The peak

total wind pressure is the maximum wind measured over a period of time.

$$P_{z,max} = q_{z,max}C_D \quad \text{(psf)} \tag{7}$$

To account for the peak wind speed, $V_{z,max}$, a gust factor is multiplied by the steady-state velocity. A gust factor of 1.10 allows for gusts of approximately 10 seconds in duration. The peak wind velocity pressure is then derived again in order to show the limitations of the formulas.

$$q_{z,max} = 0.002558V_{z,max}^2 \quad \text{(psf)} \tag{8}$$

$$V_{z,max} = V_{30}(1.10)(Z/30)^{Xmax} \quad \text{(mph)} \tag{9}$$

X_{max} linearly reduces from:

x=0.3 at V_{30}=60 mph to x=0.143 at V_{30}=130 mph

$$X_{max} = 0.3-(0.3-0.143)[(V_{z,max}-60)/(130-60)] \tag{10}$$

The limitation in equation (10) is that whenever $V_{z,max}$ exceeds 130 mph an error will be present. When the steady-state wind velocity is 125 mph then:

$$V_{z,max} = 125 \text{ mph } (1.10) = 137.5 \text{ mph}$$

Using a peak wind velocity of 137.5 mph yields an error of 5.8 percent. An error this size should be accounted for only when dealing with a steady-state 125-mph wind in peak velocity pressure calculations. Substituting (8), (9), (10), and (5) into (7) yields:

$$P_{z,max} = 0.002558[(V_{30})(1.10)(Z/30)^{[0.3-0.157[((Vz)(1.10)-60)/70]]}]^2(1.3) \quad \text{(psf)} \tag{11}$$

2.2.1.3 Steady-State Wind Velocity Profile, V_z. The following formula is the wind velocity profile for 0 to 500 feet.

$$V_z = V_{30}(Z/30)^x \quad \text{(mph)} \tag{12}$$

$$V_z = V_{30}(Z/30)^{0.3-0.157[(VZ-60)/70]} \quad \text{(mph)} \tag{13}$$

2.2.2 AMERICAN NATIONAL STANDARD INSTITUTE (ANSI) A58.1-1982. The following three subsections present the formulas for the steady-state total wind pressure, peak total wind pressure, and

steady-state wind velocity profile for ANSI A58.1-1982, conforming to the criteria of 2.1 in this report (see references 1, 5, and 6).

2.2.2.1 Steady-State Total Wind Pressure, P_z. This subsection presents the formulas for the steady-state total wind pressure. Formula (19) is the complete formula for the steady-state total wind pressure.

$$P_z = q_z C_p \quad \text{(psf)} \tag{14}$$

$$q_z = 0.00256 K_z (I V_{33})^2 \quad \text{(psf)} \tag{15}$$

$$K_z = 2.58 (Z/Z_g)^{2/a} \quad \text{for } 15 \text{ ft} \leq Z \leq Z_g \tag{16}$$

$$I = 1.11 \tag{17}$$

The external pressure coefficient, C_p, is the sum of the windward and leeward sides.

$$C_p = 1.3 \tag{18}$$

Substituting (15), (16), (17), and (18) into (14) yields:

$$P_z = 0.00256 [2.58 (Z/Z_g)^{2/a}] \{1.11 V_{33}]\}^2 (1.3) \quad \text{(psf)} \tag{19}$$

For an Exposure D: a=10.0 and Z_g=700 feet

2.2.2.2 Peak Total Wind Pressure, $P_{z,max}$. This subsection presents the formulas for the peak total wind pressure. Formula (24) is the complete formula for the peak total wind pressure.

$$P_{z,max} = q_{z,max} G_z C_p \quad \text{(psf)} \tag{20}$$

Equation (20) was modified by substituting G_z for G_h. This had to be done in order to vary the building height from 30 feet to 500 feet.

$$q_{z,max} = 0.00256 K_z (I V_z)^2 \quad \text{(psf)} \tag{21}$$

$$G_z = 0.65 + 3.65 T_z \tag{22}$$

$$T_z = 2.35 D_o^{0.5} / (Z/30)^{1/a} \tag{23}$$

Substituting (21), (22), (23), and (18) into (20) yields:

$$P_{z,max} = 0.00256[2.58(Z/Z_g)^{2/a}][1.11V_{33}]^2\{0.65 + 3.65[2.35D_o^{0.5}/(Z/30)^{1/a}]\}(1.3) \quad \text{(psf)} \qquad (24)$$

For an Exposure D: D_o=0.003

2.2.2.3 Steady-State Wind Velocity Profile, V_z. The following formula is the wind velocity profile for 0 to 500 feet.

$$V_z = V_{33}(Z_g/33)^{1/a}(Z/Z_g)^{1/a} \quad \text{(mph)} \quad \text{for } Z > 0 \qquad (25)$$

2.2.3 STANDARD BUILDING CODE. The Standard Building Code addresses only the steady-state total wind pressure which is present in the following subsection (see reference 7).

2.2.3.1 Steady-State Total Wind Pressure, P_z. This subsection presents the formula for the steady-state total wind pressure, conforming to the criteria of 2.1 in this report. Formula (26) is the complete formula for the steady-state total wind pressure.

$$P_z = 0.00256V_{30}^2(Z/30)^{2/7} \quad \text{(psf)} \quad \text{for } 30 \text{ ft} \leq Z \leq 1000 \text{ ft}$$

The Standard Building Code multiplies the wind pressure by various shape factors (SF), in order to produce the total wind pressure. The shape factor is a constant that depends on the exterior surface of the building or structure. The total wind pressure is:

$$P_z = 0.00256V_{30}^2(Z/30)^{2/7}SF \quad \text{(psf)}$$

For a vertically oriented four-wall building or structure, the shape factor is 1.3.

$$P_z = 0.00256V_{30}^2(Z/30)^{2/7}(1.3) \quad \text{(psf)} \qquad (26)$$

2.2.4 UNIFORM BUILDING CODE. The Uniform Building Code (1982 edition) was considered in this analysis. Upon investigation, it was determined that the code did not encompass Exposure D winds and, therefore, was excluded on the basis of nonconformity to the problem statement in 2.1 (see reference 8).

3. DISCUSSION

The formulas presented in section 2 were used in a spreadsheet program to produce output tables containing wind velocity at a height of 30 feet, steady-state total pressure, peak total pressure, and wind velocity at discrete heights. The output of

the spreadsheet was then passed to a presentation/graphical program which generated the figures in appendices A, B, and D that show the differences between the wind loads calculated in ASCE Paper No. 3269, ANSI A58.1-1982, and the Standard Building Code. Steady-state Exposure D winds ranging from 100 mph to 125 mph in 5-mph increments were used. The height of the wind velocity envelop ranged from 30 feet to 500 feet. Figures A-1 through A-6 show the height versus steady-state total pressure for a steady-state wind. Figure A-1 shows that for a building or structure above 330 feet, the method in ASCE Paper No. 3269 yields larger calculated velocity pressures. As the steady-state wind increases, ANSI A58.1-1982 emerges as the standard that calculates the largest total pressure, which is apparent in figures A-1 through A-3. When the steady-state wind is 110 mph and greater, ANSI A58.1-1982 analytically produces the largest total pressure, which is apparent in figures A-3 through A-6. The Standard Building Code method consistently has the lowest total pressure for figures A-1 through A-6.

Figures B-1 through B-6 in appendix B show the height versus peak total pressure for peak wind velocities. Figure B-1 shows that, for a building or structure above 250 feet, the method in ASCE Paper No. 3269 has larger calculated peak total pressures. As the peak wind velocity increases, ANSI A58.1-1982 emerges as the standard that calculates the largest total pressure, which is apparent in figures B-1 through B-4. When the peak wind is 115 mph and greater, ANSI A58.1-1982 analytically produces the largest total pressure, which is apparent in figures B-4 through B-6.

Figure C-1 in appendix C allows the designer to consider factors, such as the number of years between occurrences and what is an acceptable risk, for determining a peak wind speed. Once a peak wind speed is ascertained, the peak total pressure can be determined from appendix B.

When trying to determine which particular method calculates larger pressure values consistently regardless of the steady-state or peak winds, there is no clear-cut choice for all altitudes. For winds of 115 mph and greater, ANSI A58.1-1982 calculates larger total pressure for both steady-state and peak winds. Below 250 feet for all wind speeds, both steady-state and peak, ANSI A58.1-1982 calculates the larger pressure. For winds between 100 mph and 110 mph and for buildings or structures between 250 feet and 500 feet tall, there is no clear-cut choice of which code produces the largest total pressure. The choice of which code to use depends on the wind type and wind speed. An

example of this can be seen in figures A-1 and B-1 for a 275-foot-tall building or structure acted upon by a 100-mph wind. Figure A-1, which uses steady-state winds, indicates that the ANSI A58.1-1982 method calculates a larger velocity pressure than the ASCE Paper No. 3269 method; however, figure B-1, which uses peak wind rather than steady-state wind, indicates that the ASCE Paper No. 3269 method should be used instead of ANSI A58.1-1982. The dilemma over which method to use can be eliminated if the question of which type of wind should a building or structure be designed for (a steady-state or peak wind) is answered.

Figures D-1 through D-6 in appendix D show the calculated wind velocity profile from the methods in ASCE Paper No. 3269 and ANSI A58.1-1982.

Appendix E contains all of the formulas used in a spreadsheet program to produce tables E-1 through E-6 that contain all of the data points used to generate the graphs in appendices A through D.

4. SUMMARY OF RESULTS

This analysis used a Category III building or structure exposed to an Exposure D steady-state wind varying from 100 mph to 125 mph in 5-mph increments to compare methods of calculating wind load pressure specified in ASCE Paper no. 3269, ANSI A58.1-1982, the Standard Building Code, and the Uniform Building Code. The wind velocity envelop ranged from 30 feet to 500 feet. It was determined that the method for the calculation of wind load pressure specified in ANSI A58.1-1982 produces a larger wind load pressure for a building or structure less than or equal to 250 feet in height, acted upon by a wind greater than or equal to 115 mph, than the other methods. For a building or structure between 250 feet and 500 feet tall acted upon by a wind ranging between 100 mph and 110 mph, there is no definitive choice of which method to use. Factors that must be considered for a building or structure in this range are steady-state or peak wind velocity, geographic location, distance from a large open body of water (i.e., an ocean or enormous lake), and the expected design life and its risk factor. It was determined that the Standard Building Code consistently yielded the lowest steady-state total pressure values as compared to the other methods. The Standard Building Code did not address either the peak total pressure or the wind velocity profile. The Uniform Building Code did not encompass Exposure D winds and, therefore, was excluded on the basis of nonconformity to the specified winds.

APPENDIX A

TOTAL PRESSURE FOR A STEADY-STATE WIND VELOCITY

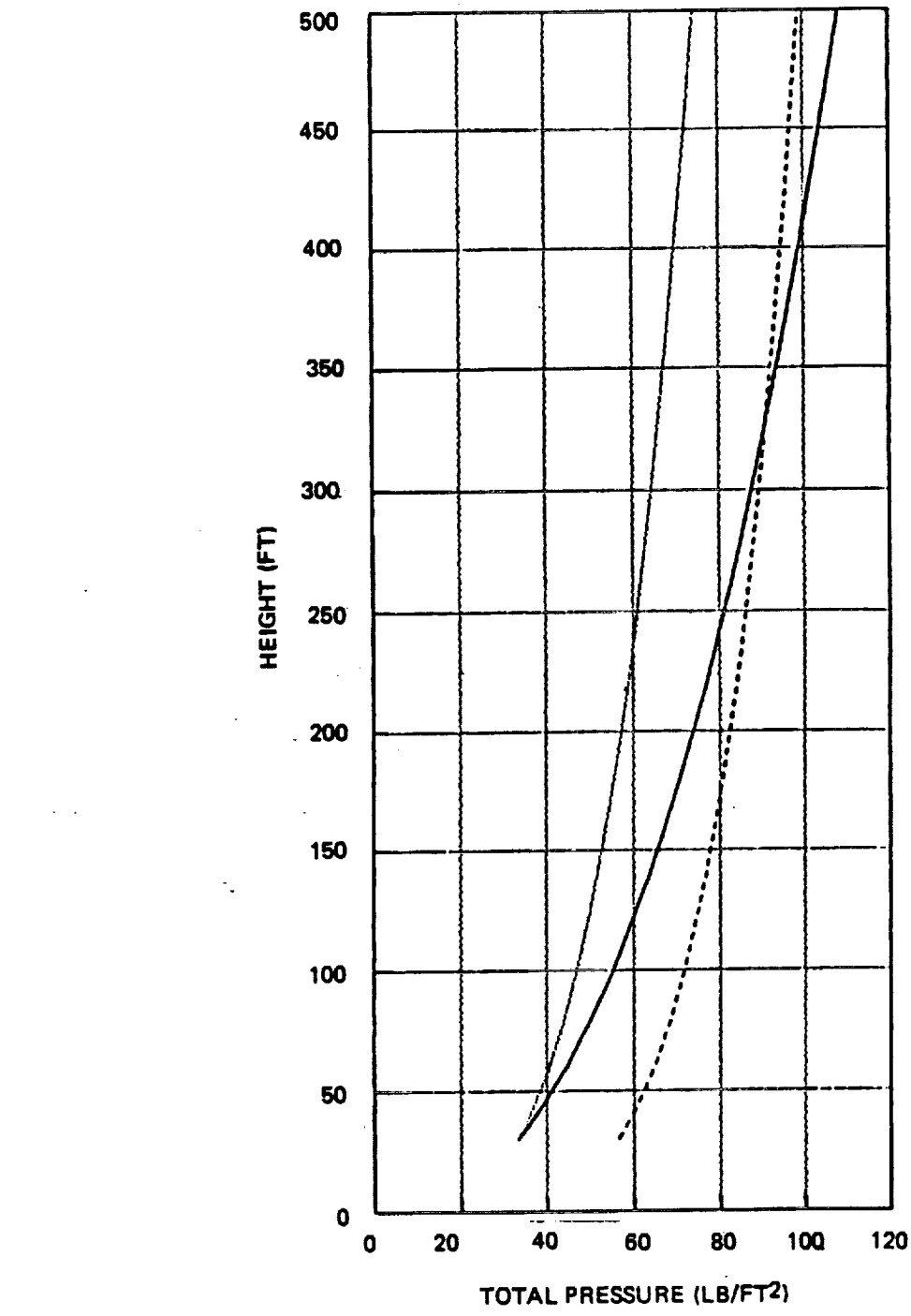

Figure A-1. Height Versus Total Pressure: Wind Velocity 100 mph at 33 ft

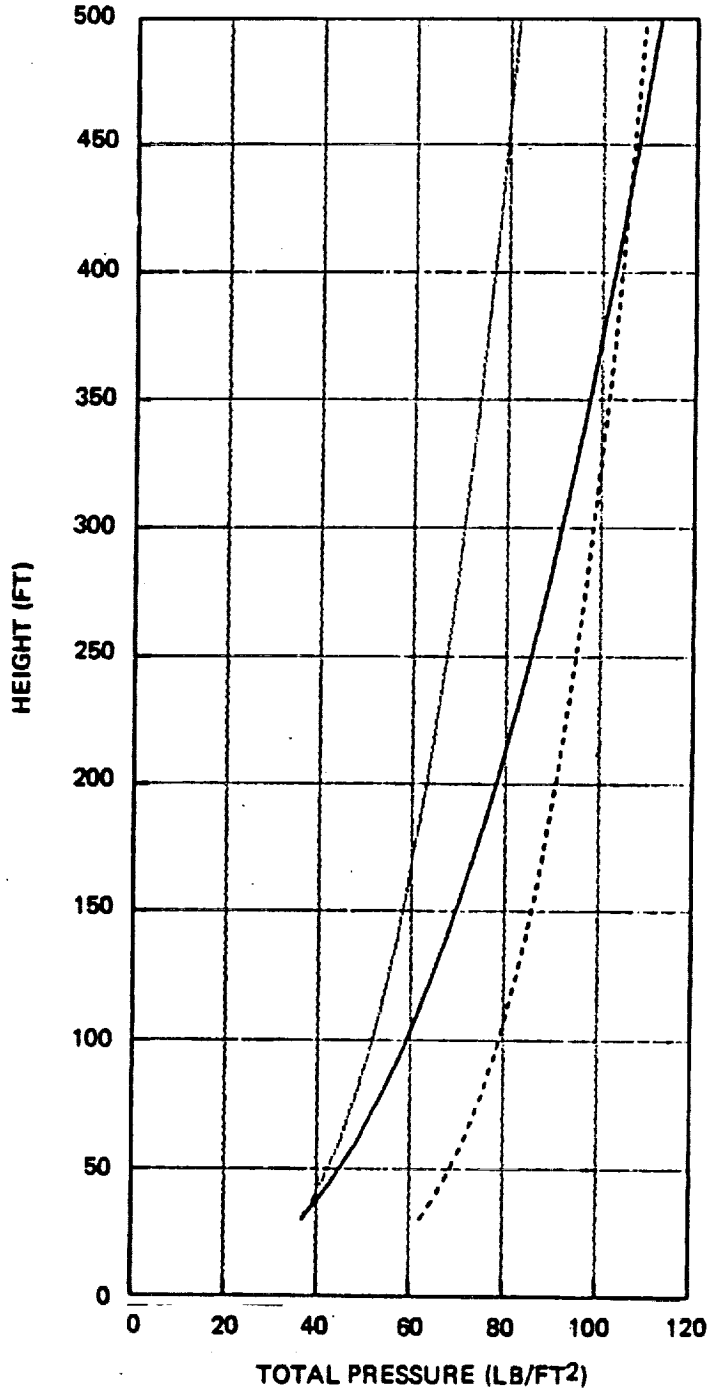

Figure A-2. Height Versus Total Pressure: Wind Velocity 105 mph at 33 ft

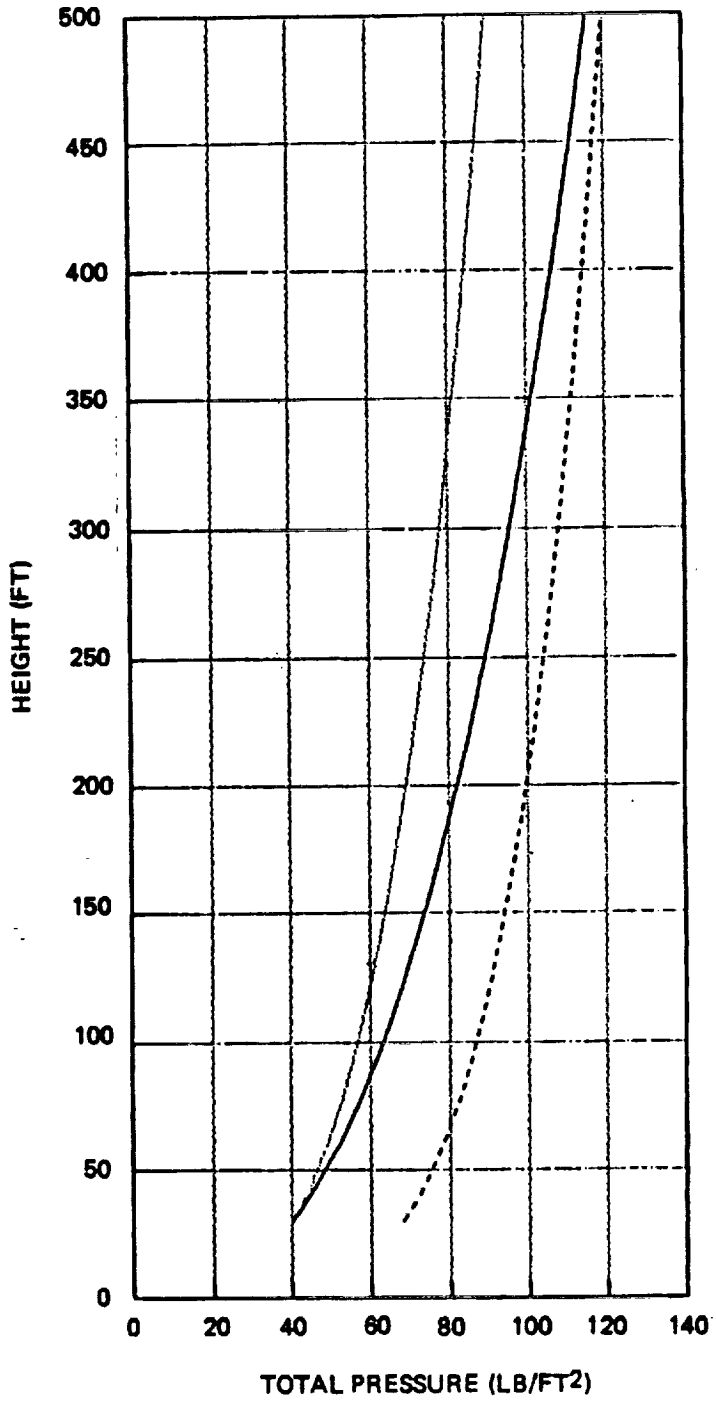

Figure A-3. Height Versus Total Pressure: Wind Velocity 110 mph at 33 ft

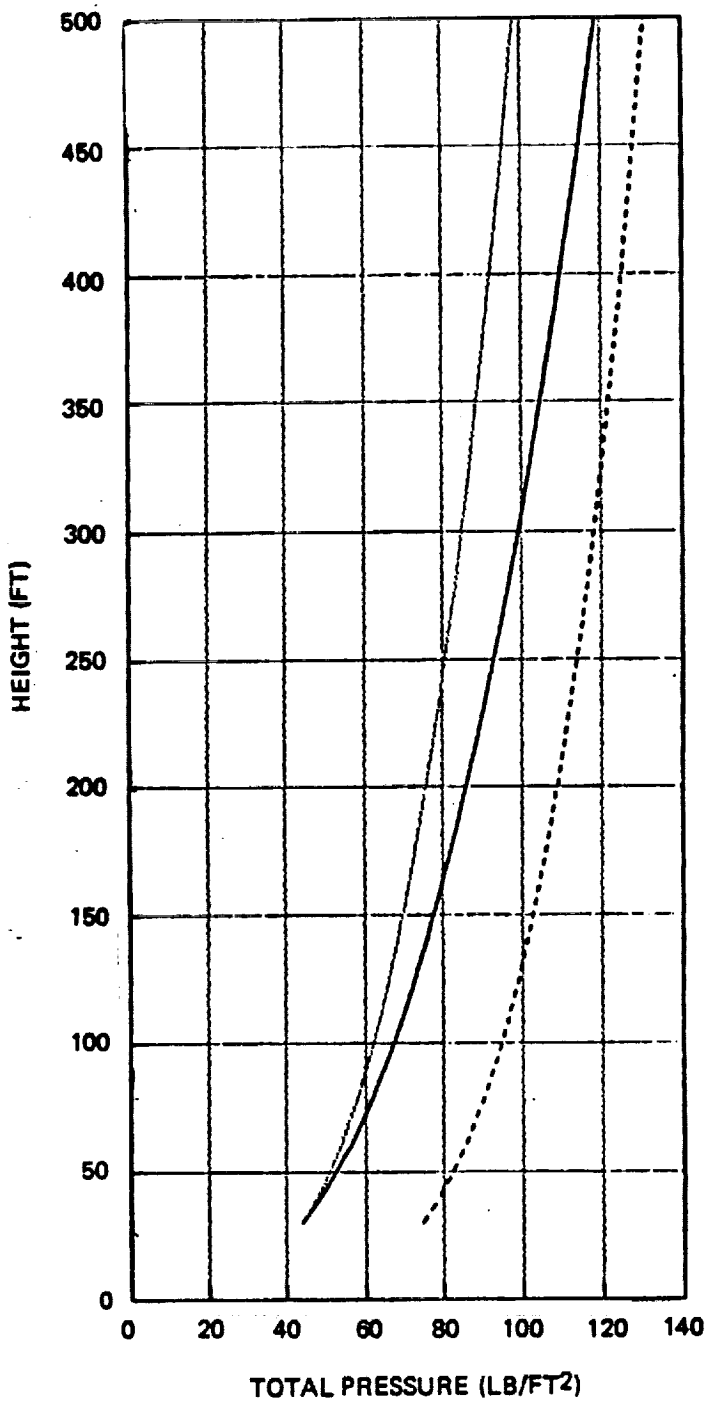

Figure A-4. Height Versus Total Pressure: Wind Velocity 115 mph at 33 ft

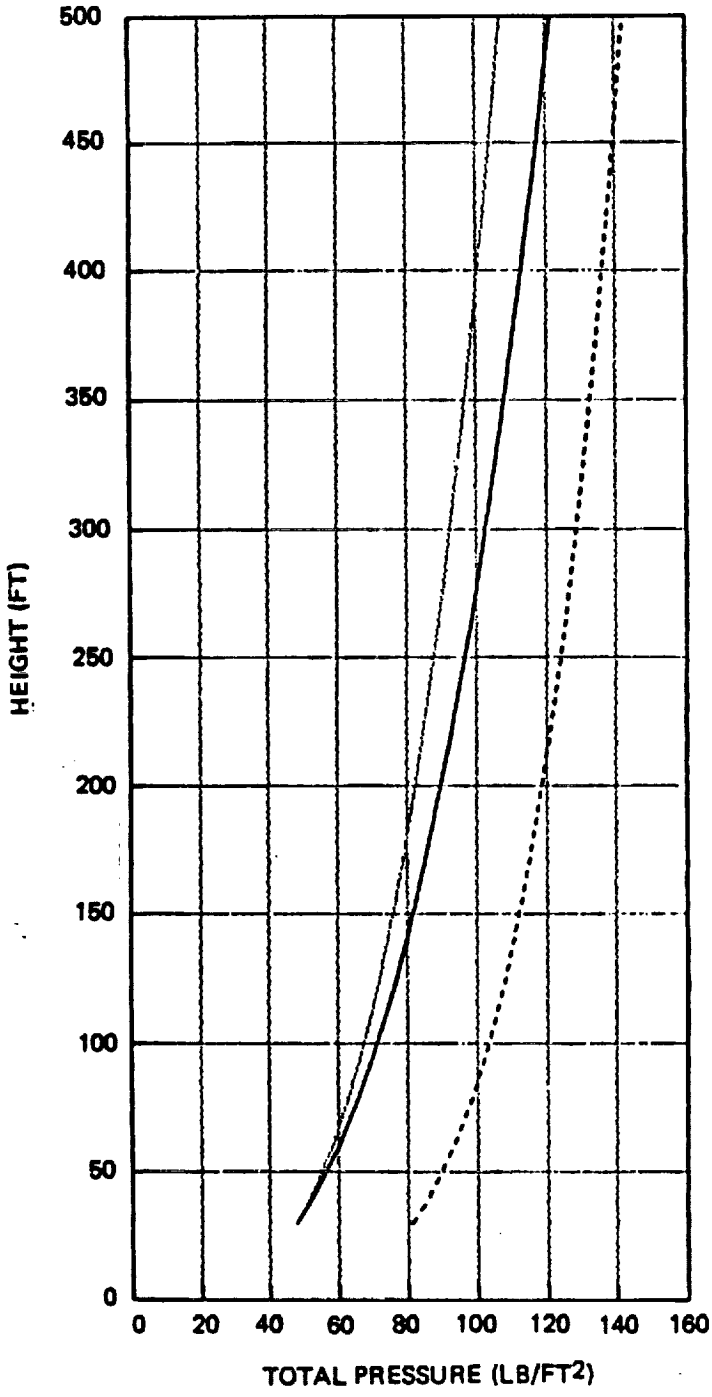

Figure A-5. Height Versus Total Pressure:
Wind Velocity 120 mph at 33 ft

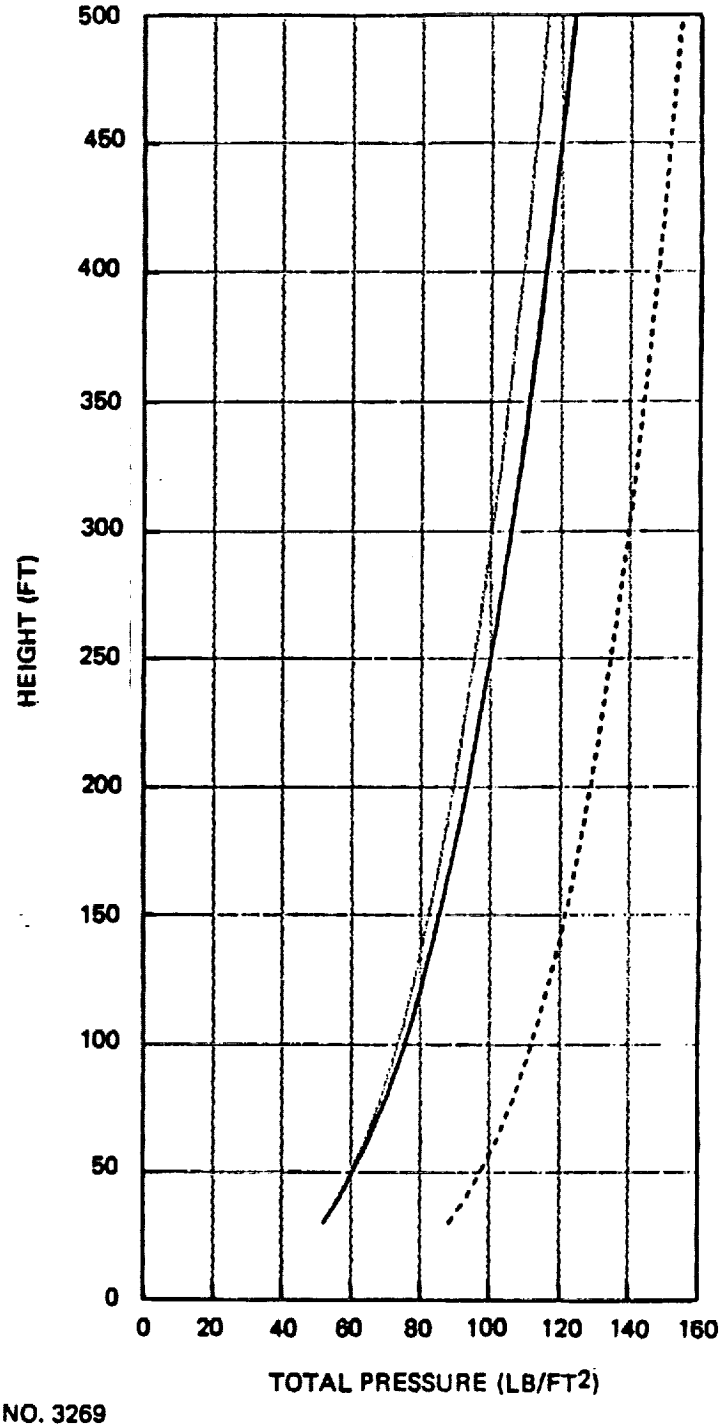

Figure A-6. Height Versus Total Pressure:
Wind Velocity 125 mph at 33 ft

APPENDIX B

PEAK TOTAL PRESSURE FOR A PEAK WIND VELOCITY

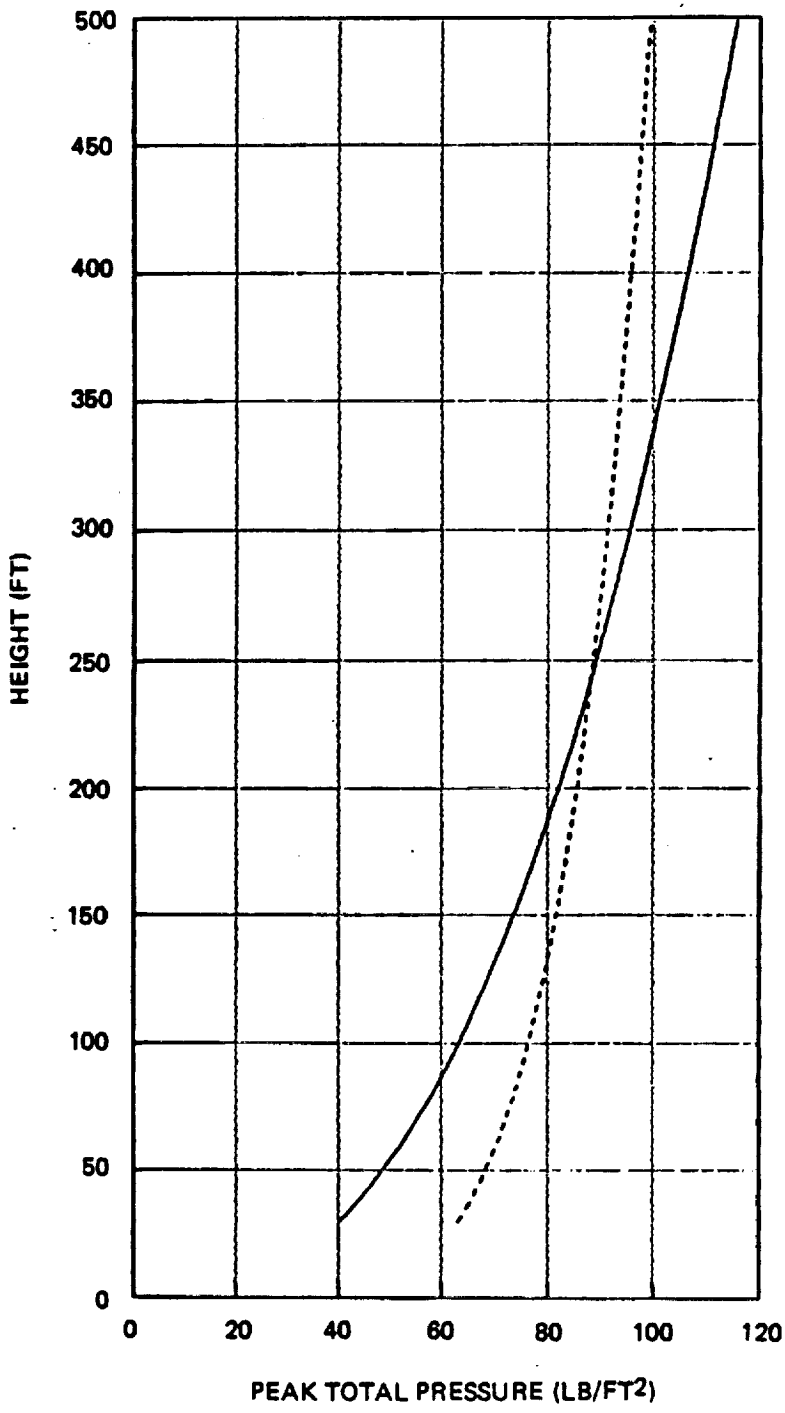

Figure B-1. Height Versus Peak Total Pressure: Wind Velocity 100 mph at 33 ft

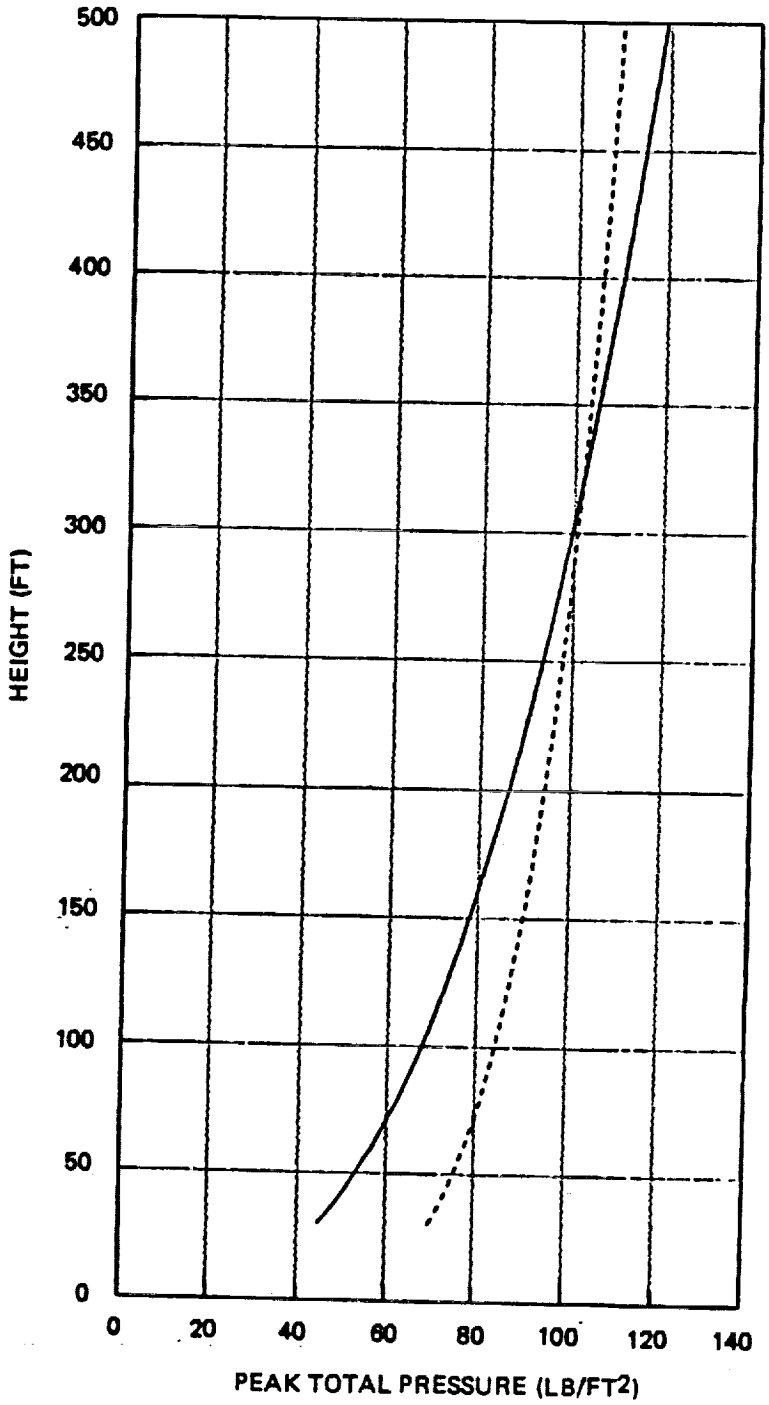

Figure B-2. Height Versus Peak Total Pressure: Wind Velocity 105 mph at 33 ft

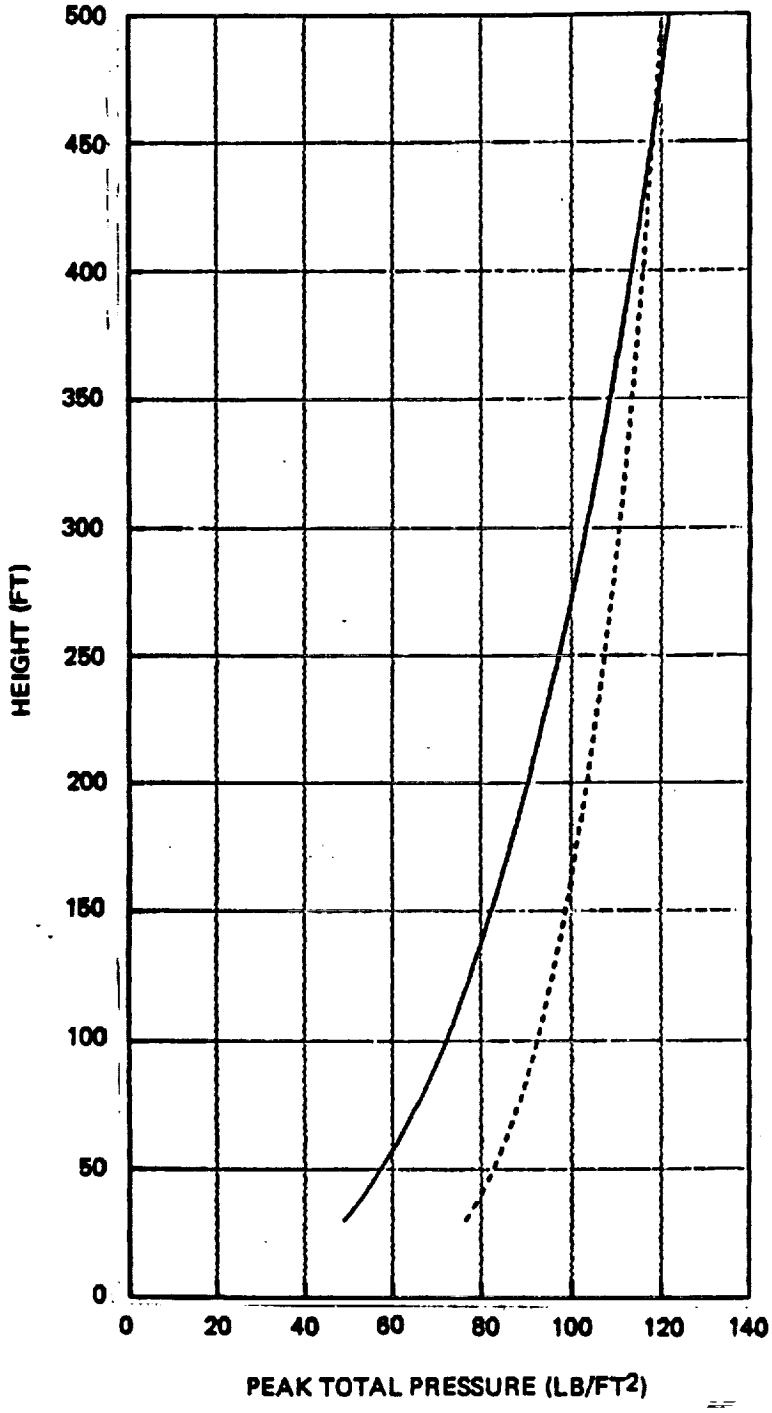

Figure B-3. Height Versus Peak Total Pressure: Wind Velocity 110 mph at 33 ft

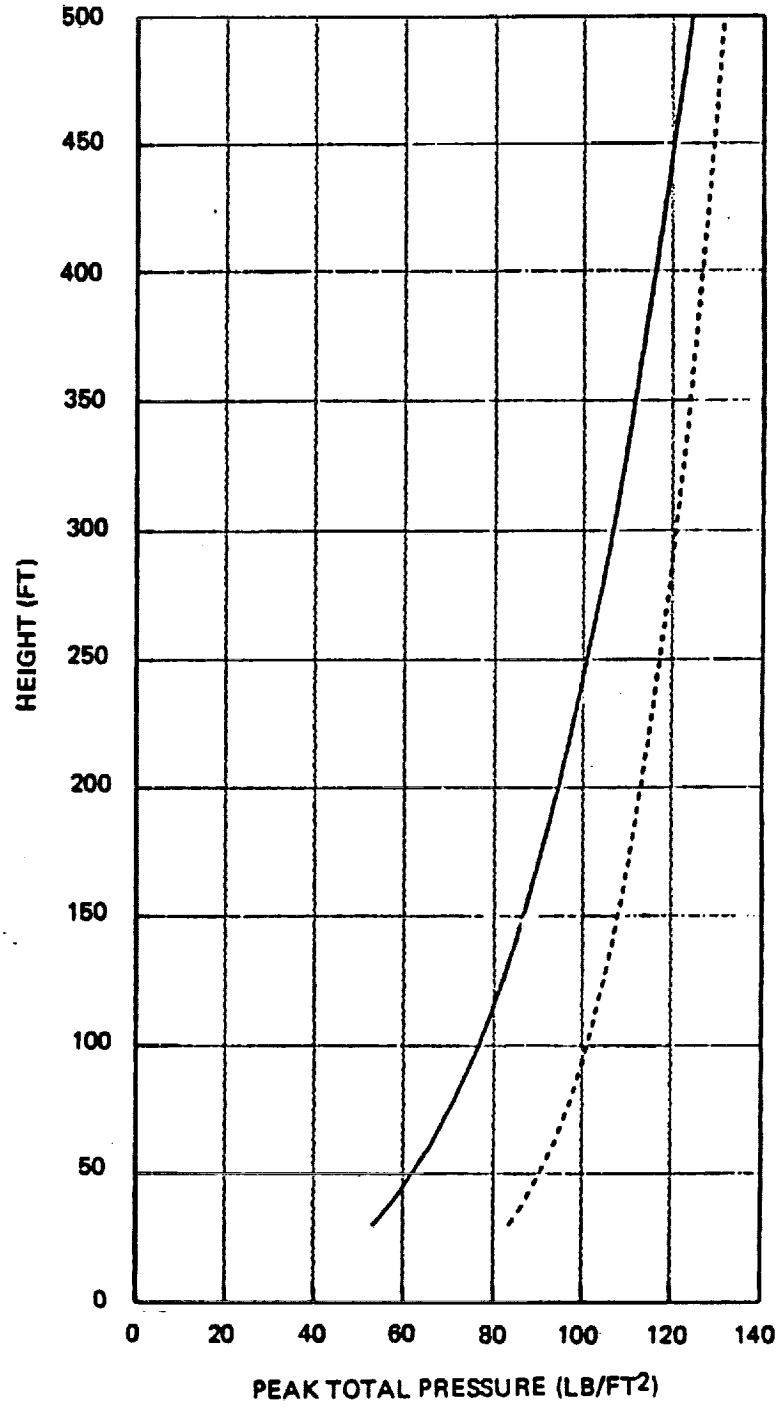

Figure B-4. Height Versus Peak Total Pressure: Wind Velocity 115 mph at 33 ft

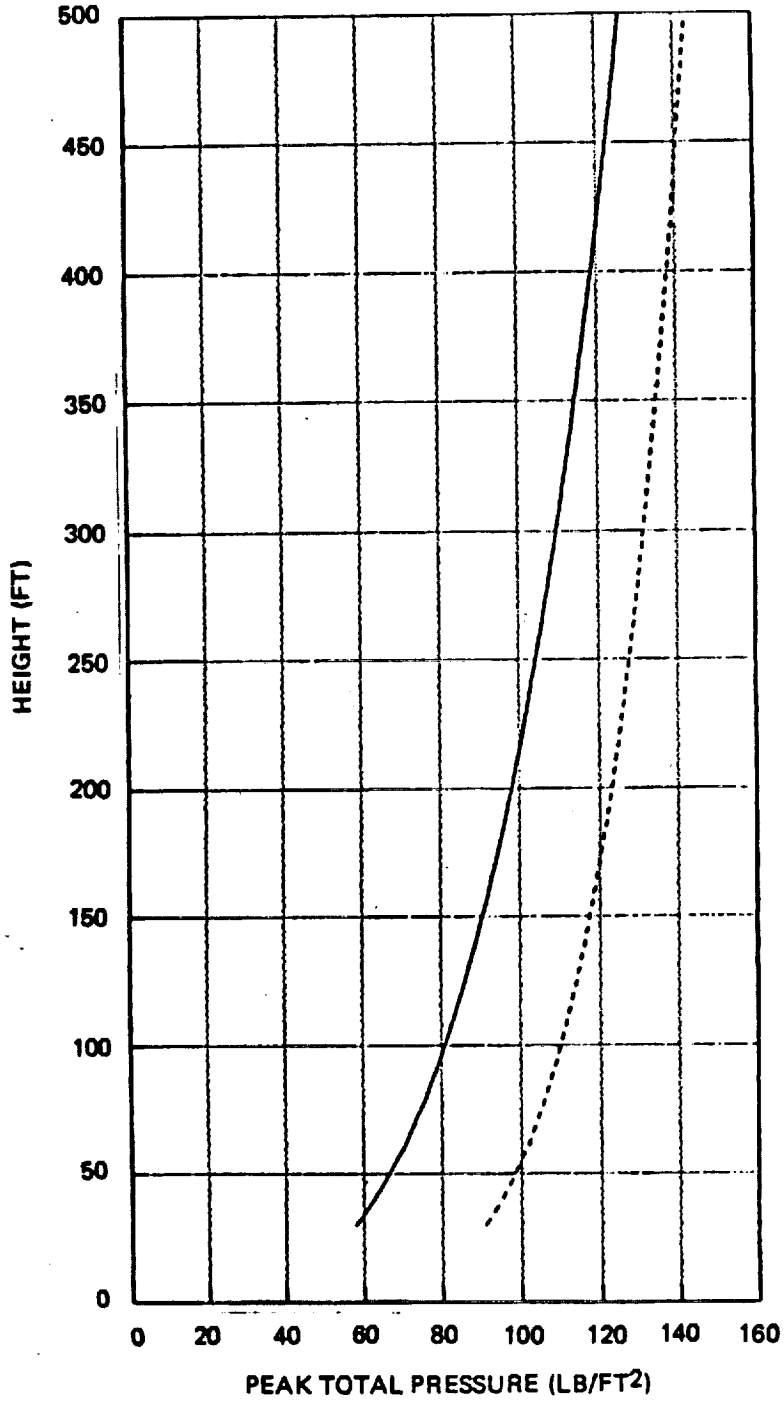

Figure B-5. Height Versus Peak Total Pressure: Wind Velocity 120 mph at 33 ft

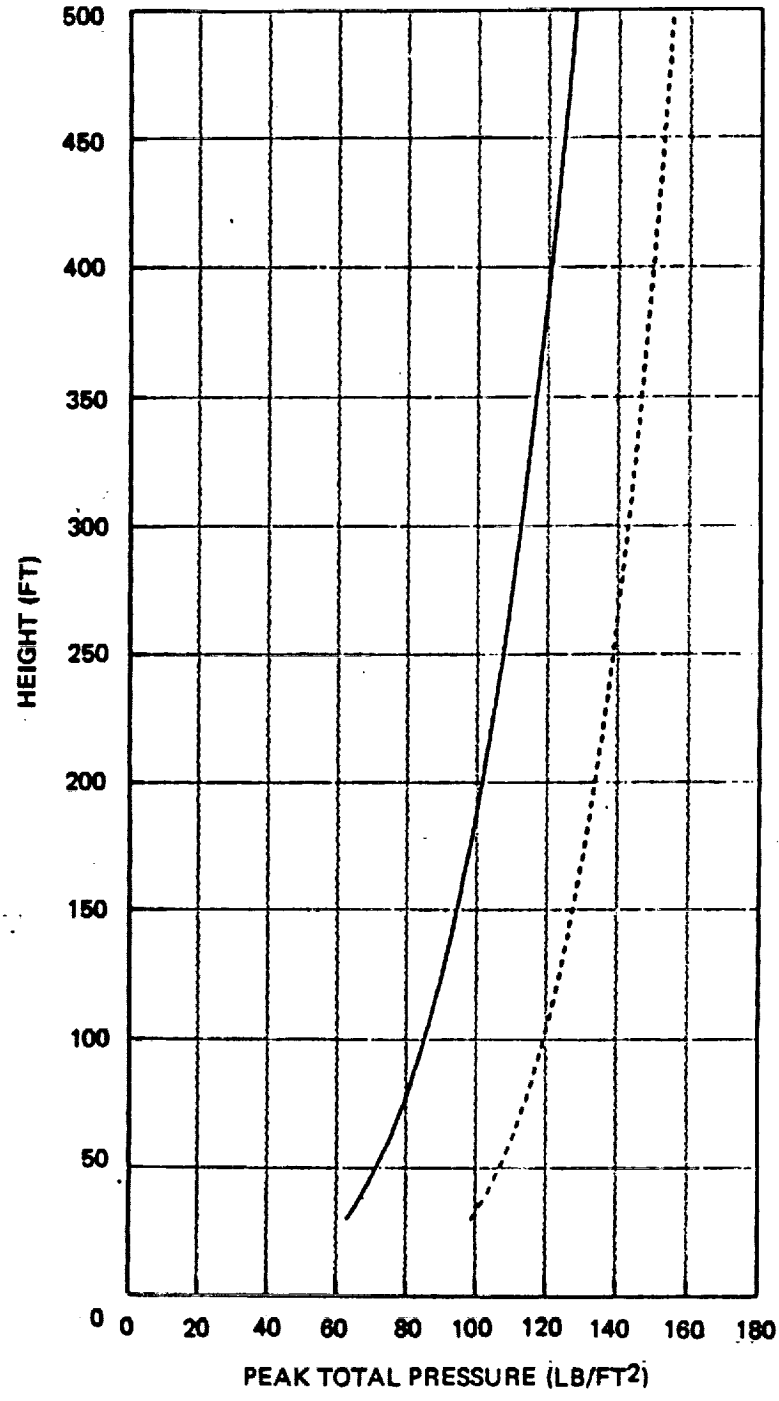

Figure B-6. Height Versus Peak Total Pressure: Wind Velocity 125 mph at 33 ft

APPENDIX C

FACILITY DESIGN WIND FOR VARIOUS PEAK WIND SPEEDS AND LIFETIMES

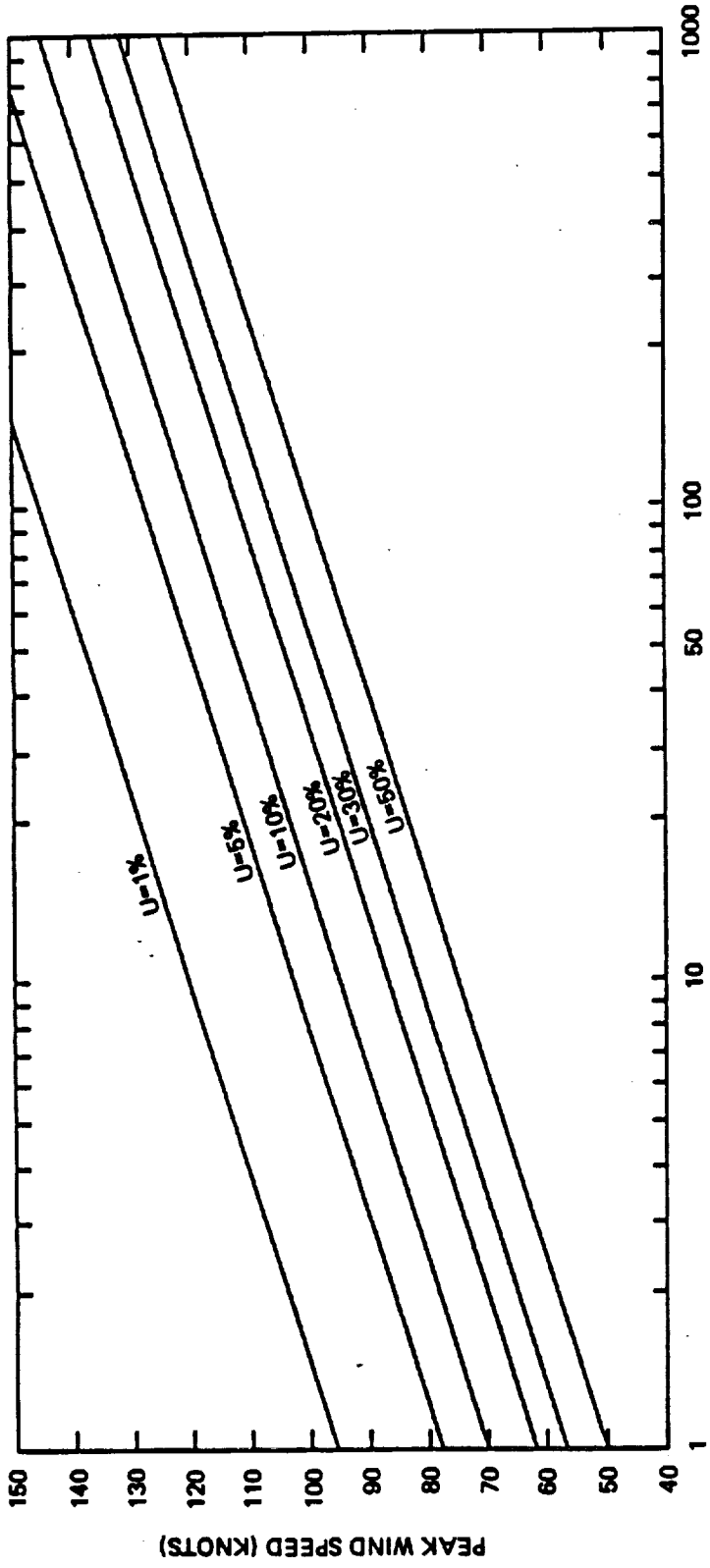

Figure C-1. Facility Design Winds for Various Peak Wind Speeds and Lifetimes

APPENDIX D

WIND VELOCITY PROFILE

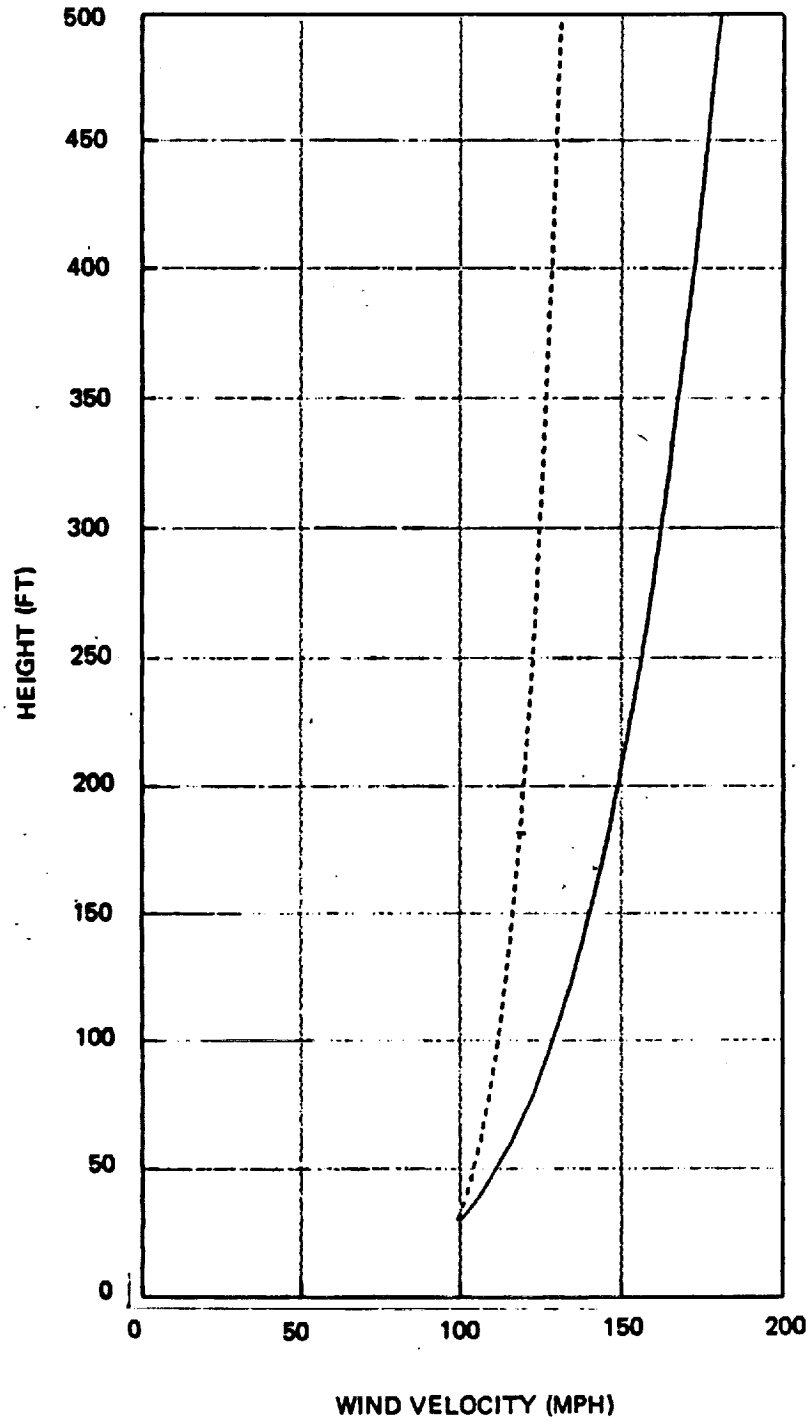

Figure D-1. Height Versus Wind Velocity: Velocity Profile 100 mph at 33 ft

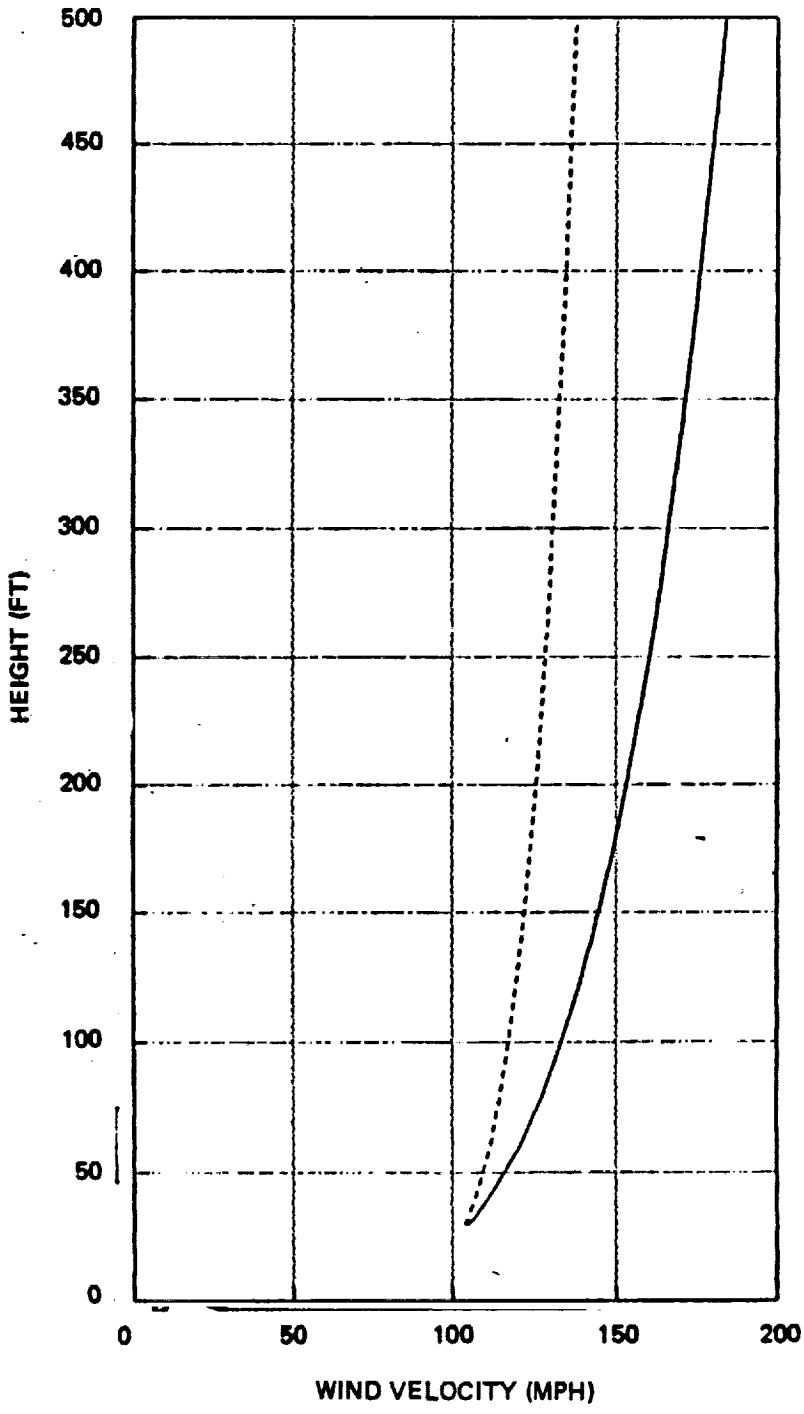

Figure D-2. Height Versus Wind Velocity: Velocity Profile 105 mph at 33 ft

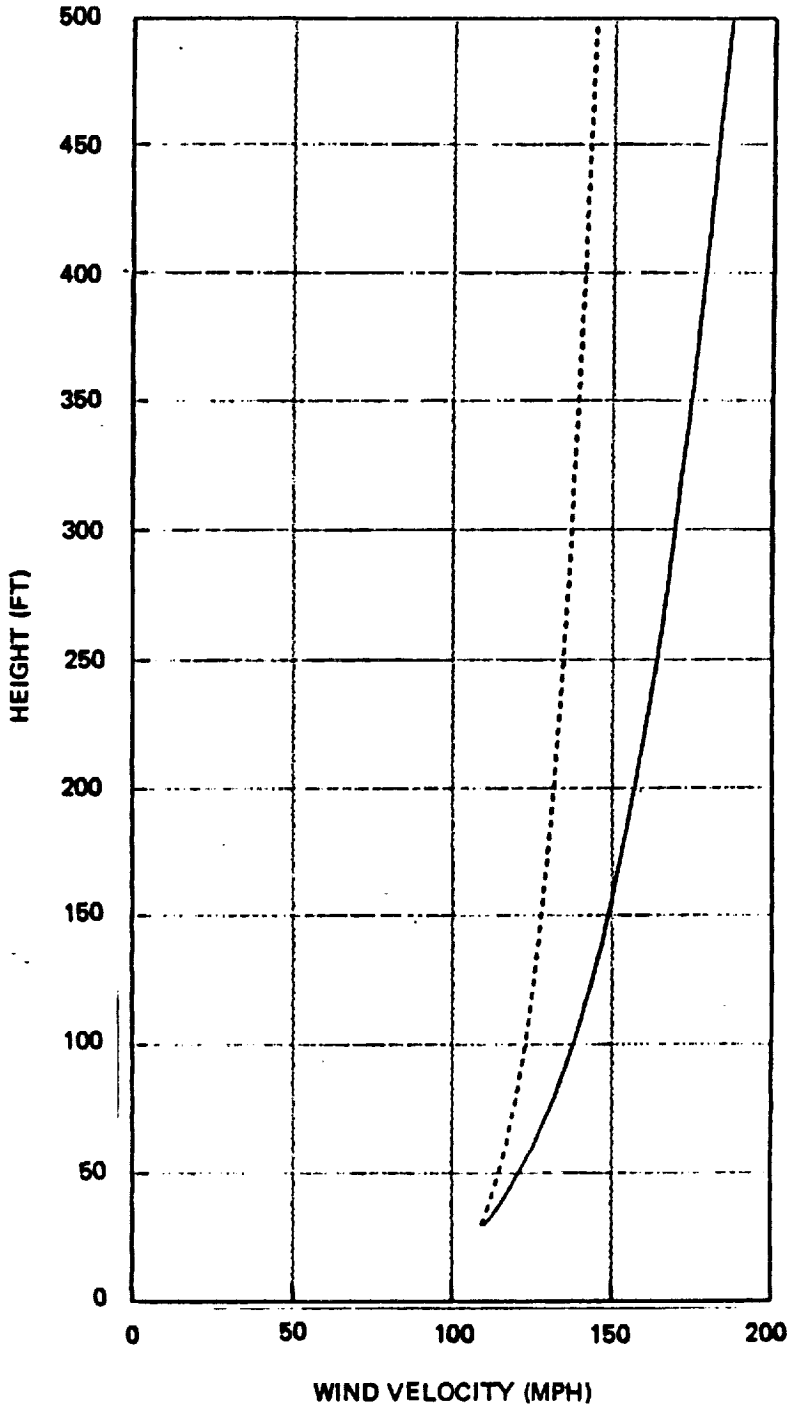

Figure D-3. Height Versus Wind Velocity: Velocity Profile 110 mph at 33 ft

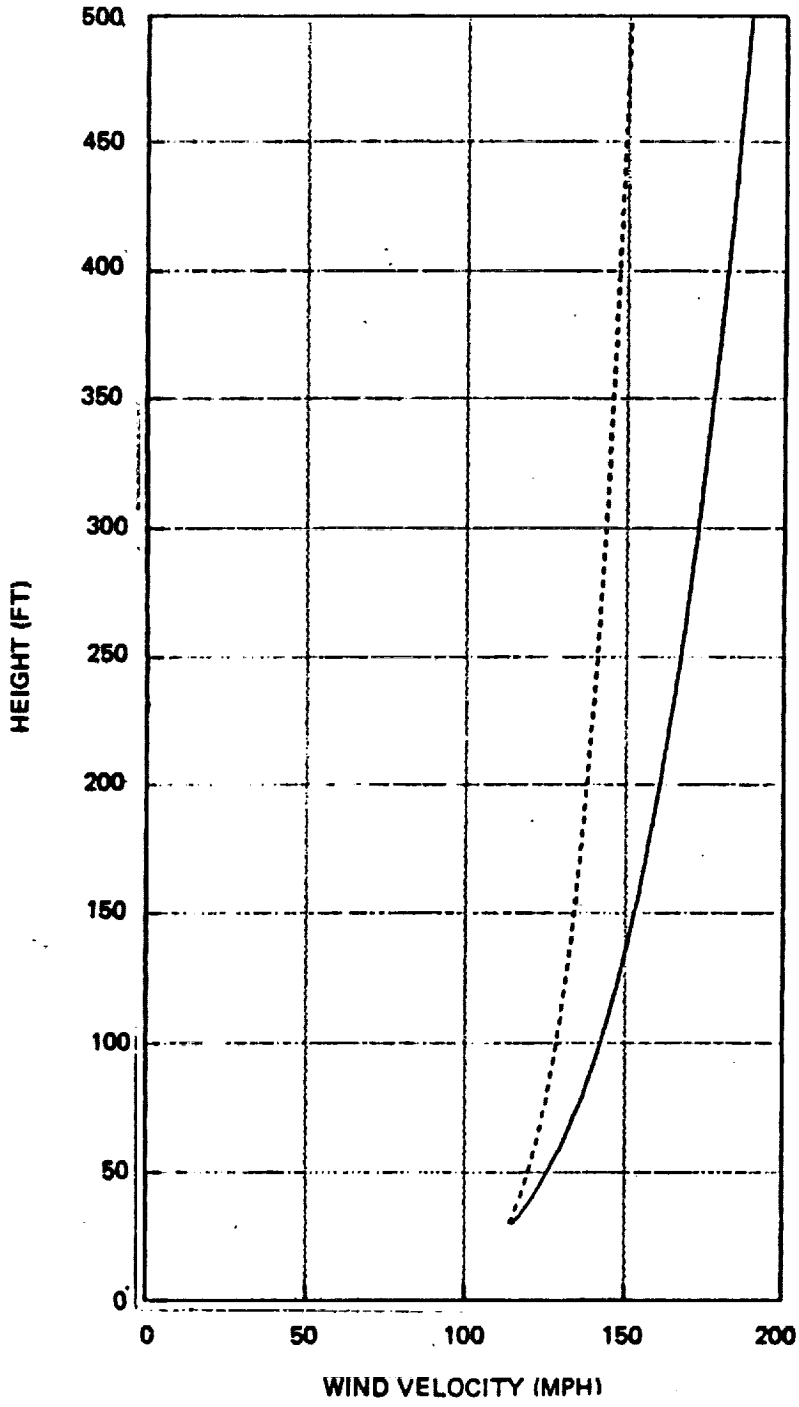

Figure D-4. Height Versus Wind Velocity: Velocity Profile 115 mph at 33 ft

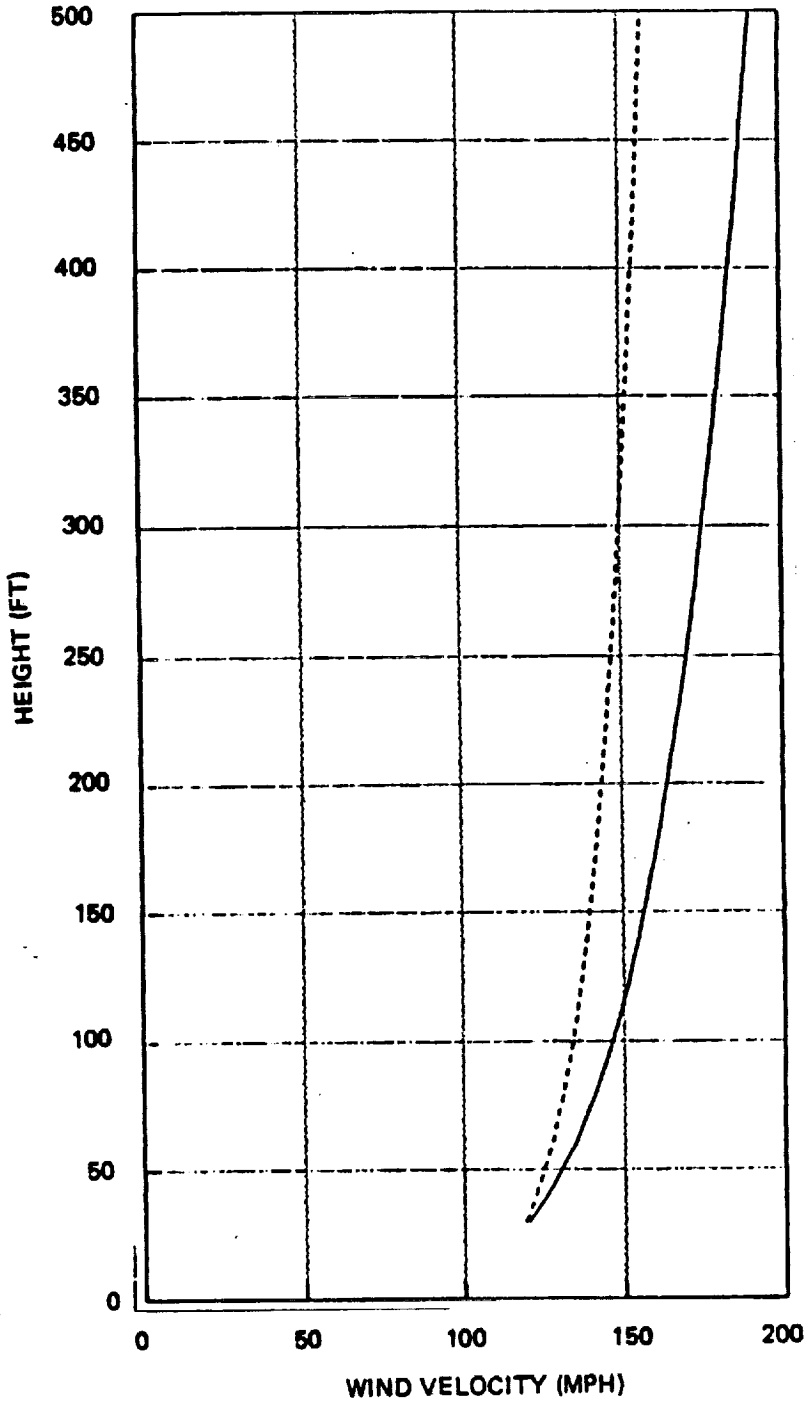

Figure D-5. Height Versus Wind Velocity: Velocity Profile 120 mph at 33 ft

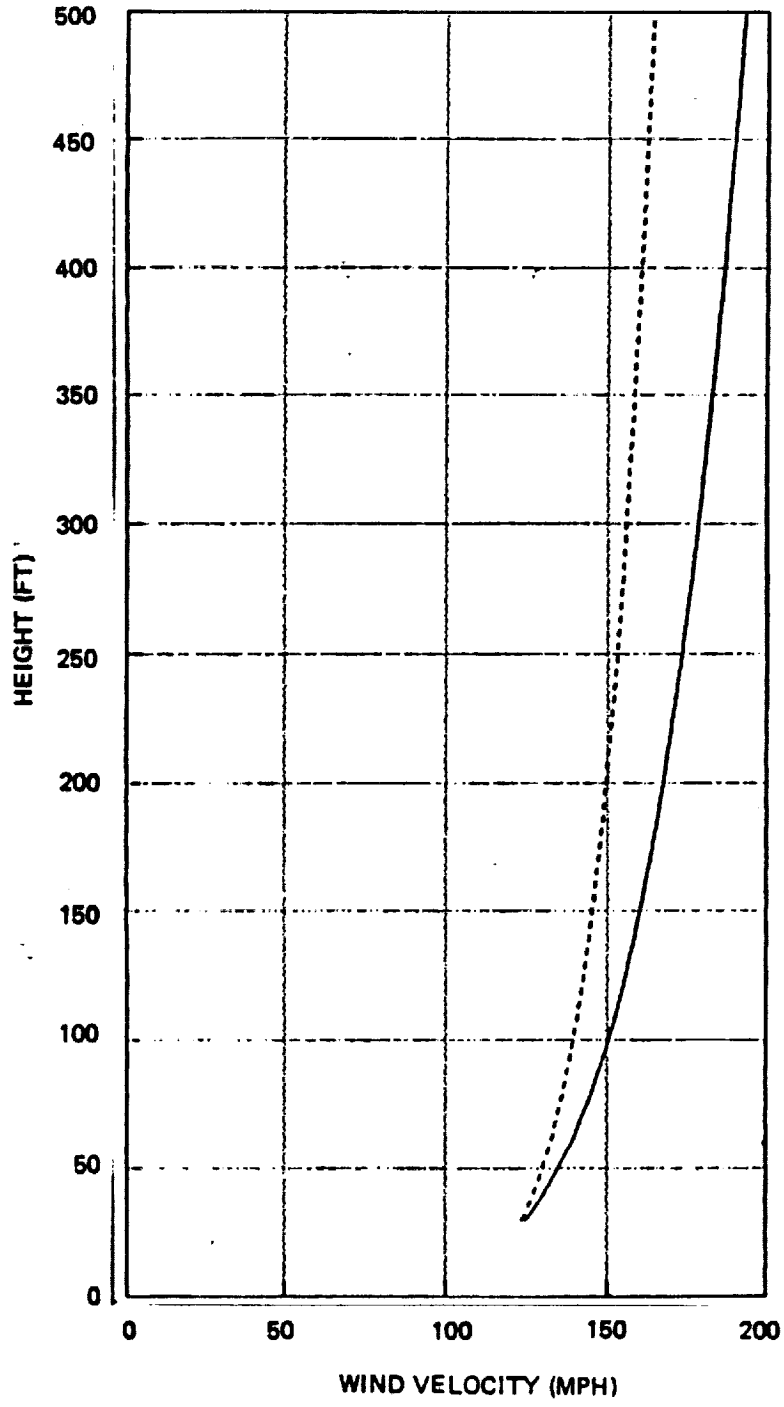

Figure D-6. Height Versus Wind Velocity: Velocity Profile 125 mph at 33 ft

APPENDIX E

WIND PRESSURE AND WIND VELOCITY AT VARIOUS HEIGHTS FOR SPECIFIC HURRICANE WIND SPEEDS AT 33 FEET

FORMULAS

The inputs for all of the formulas are height (located in column A) and steady-state wind velocity (located in column D). Columns B, C, and D are "HIDDEN" from view in order to produce a pretty print out. The formulas used in spread sheet are located below in the order that they appear from right to left. All of the formulas shown come from row 12 which is the row corresponding to 30 feet.

Coefficient X used for steady-state winds (column B):

```
0.3-(0.3-0.143)*((D12-60)/(130-60))
```

Coefficient X-max used for peak winds (coluen C):

```
0.3-(0.3-0.143)*(((D12*1.1)-60)/(130-60))
```

ASCE Paper No. 3269 Steady-state Total Pressure (psf) (column F):

```
0.002558*((D12*((A12/30)^B12))^2)*(1.3)
```

ANSI A58.1-1982 Steady-state Total Pressure (psf) (column H):

```
0.00256*2.58*((A12/700)^(2/10))*((1.11*D12)^2)*1.3
```

Standard Building Code Steady-state Total Pressure (psf) (column J):

```
0.00256*(D12^2)*((A12/30)^(2/7))*(1.3)
```

ASCE Paper No. 3269 Peak Total Pressure (psf) (column L):

```
0.002558*((((D12*1.1))*(((A12/30)^C12)))^2)*1.3
```

ANSI A58.1-1982 Peak Total Pressure (psf) (column N):

```
0.00256*(2.58*((A12/700)^(2/10))*((1.11*D12)^2)*
(0.65+(3.65*(2.35*((0.003)^0.5)/((A12/30)^(1/10))))))*1.3
```

ASCE Paper No. 3269 Velocity Profile (mph) (column P):

```
D12*((A12/30)^B12)
```

ANSI A58.1-1982 Velocity Profile (mph) (column R):

```
(F12*((700/33)^(1/10)))*((D12/700)^(1/10))
```

ASSUMPTIONS:

1. Exposure D steady-state winds.
2. Risks of wind reacurance were 50 and 100 years (a choice of risks were not available).
3. Catagory III building.
4. Primary frames and systems transmit the load (not cladding).
5. Only the windward side and leeward side of the building or structure were analized. The roof was not considered.
6. The building is rectangular (not thin) with four vertically oriented walls.

WIND LOADING PRESSURE ANALYSIS FOR A STEADY-STATE WIND = 100.00 MPH AT 30 FEET
EXPOSURE D, CATAGORY III BUILDING

HEIGHT, Z (ft)	ASCE Paper No. 3269 Steady-state Total Pressure (psf)	ANSI A58.1-1982 Steady-state Total Pressure (psf)	Standard Building Code Steady-state Total Pressure (psf)	ASCE Paper No. 3269 Peak Total Pressure (psf)	ANSI A58.1-1982 Peak Total Pressure (psf)	ASCE Paper No. 3269 Velocity Profile (mph)	ANSI A58.1-1982 Velocity Profile (mph)
30.00	33.25	56.34	33.28	40.24	63.10	100.00	99.05
33.00	34.61	57.43	34.20	41.70	64.05	102.02	100.00
40.00	37.53	59.68	36.13	44.83	66.04	106.24	101.94
60.00	44.51	64.72	40.57	52.21	70.44	115.69	106.16
80.00	50.23	68.56	44.04	58.17	73.76	122.91	109.26
100.00	55.18	71.69	46.94	63.25	76.45	128.81	111.72
120.00	59.57	74.35	49.45	67.74	78.73	133.85	113.78
140.00	63.56	76.68	51.68	71.78	80.72	138.26	115.55
160.00	67.24	78.75	53.69	75.47	82.48	142.19	117.10
180.00	70.65	80.63	55.53	78.88	84.07	145.76	118.49
200.00	73.85	82.34	57.23	82.07	85.53	149.02	119.74
220.00	76.87	83.93	58.80	85.06	86.86	152.04	120.89
240.00	79.74	85.40	60.28	87.89	88.10	154.85	121.95
260.00	82.47	86.78	61.68	90.57	89.26	157.48	122.93
280.00	85.08	88.08	63.00	93.13	90.35	159.95	123.84
300.00	87.58	89.30	64.25	95.57	91.37	162.29	124.70
320.00	89.99	90.46	65.45	97.92	92.34	164.51	125.51
340.00	92.32	91.56	66.59	100.18	93.26	166.62	126.27
360.00	94.56	92.62	67.69	102.35	94.14	168.63	126.99
380.00	96.74	93.62	68.74	104.45	94.98	170.56	127.68
400.00	98.85	94.59	69.76	106.48	95.78	172.41	128.34
420.00	100.90	95.52	70.74	108.45	96.55	174.19	128.97
440.00	102.89	96.41	71.68	110.37	97.29	175.90	129.57
460.00	104.83	97.27	72.60	112.23	98.01	177.55	130.14
480.00	106.72	98.10	73.49	114.03	98.70	179.15	130.70
500.00	108.57	98.91	74.35	115.80	99.36	180.69	131.23

Figure E-1. Wind Pressure and Wind Velocity for 100 mph at 33 ft

WIND LOADING PRESSURE ANALYSIS FOR A STEADY-STATE WIND = 105.00 MPH AT 30 FEET
EXPOSURE D, CATAGORY III BUILDING

HEIGHT, Z (ft)	ASCE Paper No. 3269 Steady-state Total Pressure (psf)	ANSI A58.1-1982 Steady-state Total Pressure (psf)	Standard Building Code Steady-state Total Pressure (psf)	ASCE Paper No. 3269 Peak Total Pressure (psf)	ANSI A58.1-1982 Peak Total Pressure (psf)	ASCE Paper No. 3269 Velocity Profile (mph)	ANSI A58.1-1982 Velocity Profile (mph)
30.00	36.66	62.12	36.69	44.36	69.56	105.00	104.00
33.00	38.08	63.32	37.70	45.87	70.62	107.01	105.00
40.00	41.11	65.80	39.83	49.08	72.81	111.19	107.04
60.00	48.31	71.36	44.73	56.58	77.66	120.54	111.47
80.00	54.18	75.58	48.56	62.60	81.32	127.64	114.72
100.00	59.21	79.03	51.76	67.70	84.29	133.44	117.31
120.00	63.67	81.97	54.52	72.17	86.80	138.37	119.47
140.00	67.70	84.53	56.98	76.18	88.99	142.68	121.33
160.00	71.40	86.82	59.19	79.84	90.94	146.53	122.96
180.00	74.82	88.89	61.22	83.21	92.69	150.00	124.41
200.00	78.03	90.78	63.09	86.34	94.29	153.18	125.73
220.00	81.05	92.53	64.83	89.28	95.77	156.12	126.93
240.00	83.90	94.16	66.46	92.05	97.13	158.84	128.04
260.00	86.62	95.68	68.00	94.67	98.41	161.39	129.07
280.00	89.21	97.10	69.46	97.17	99.61	163.79	130.03
300.00	91.70	98.45	70.84	99.55	100.74	166.06	130.93
320.00	94.09	99.73	72.16	101.83	101.81	168.21	131.78
340.00	96.38	100.95	73.42	104.02	102.82	170.25	132.58
360.00	98.60	102.11	74.63	106.13	103.79	172.20	133.34
380.00	100.75	103.22	75.79	108.17	104.71	174.06	134.07
400.00	102.83	104.28	76.91	110.13	105.60	175.85	134.75
420.00	104.84	105.31	77.99	112.03	106.45	177.56	135.41
440.00	106.80	106.29	79.03	113.88	107.27	179.21	136.05
460.00	108.71	107.24	80.04	115.67	108.05	180.81	136.65
480.00	110.57	108.16	81.02	117.41	108.81	182.35	137.23
500.00	112.38	109.04	81.97	119.10	109.55	183.83	137.80

Figure E-2. Wind Pressure and Wind Velocity for 105 mph at 33 ft

WIND LOADING PRESSURE ANALYSIS FOR A STEADY-STATE WIND = 110.00 MPH AT 30 FEET
EXPOSURE D, CATAGORY III BUILDING

HEIGHT, Z (ft)	ASCE Paper No. 3269 Steady-state Total Pressure (psf)	ANSI A58.1-1982 Steady-state Total Pressure (psf)	Standard Building Code Steady-state Total Pressure (psf)	ASCE Paper No. 3269 Peak Total Pressure (psf)	ANSI A58.1-1982 Peak Total Pressure (psf)	ASCE Paper No. 3269 Velocity Profile (mph)	ANSI A58.1-1982 Velocity Profile (mph)
30.00	40.24	68.18	40.27	48.69	76.35	110.00	108.96
33.00	41.70	69.49	41.38	50.23	77.50	111.99	110.00
40.00	44.83	72.21	43.72	53.48	79.90	116.11	112.14
60.00	52.21	78.32	49.09	61.05	85.23	125.30	116.78
80.00	58.17	82.95	53.29	67.06	89.25	132.26	120.19
100.00	63.25	86.74	56.80	72.12	92.51	137.92	122.90
120.00	67.74	89.96	59.84	76.54	95.27	142.72	125.16
140.00	71.78	92.78	62.53	80.49	97.67	146.92	127.10
160.00	75.47	95.29	64.97	84.08	99.80	150.65	128.81
180.00	78.88	97.56	67.19	87.37	101.73	154.02	130.34
200.00	82.07	99.64	69.24	90.43	103.49	157.10	131.72
220.00	85.06	101.55	71.15	93.29	105.10	159.94	132.98
240.00	87.89	103.34	72.94	95.97	106.60	162.57	134.14
260.00	90.57	105.00	74.63	98.52	108.00	165.03	135.22
280.00	93.13	106.57	76.23	100.93	109.32	167.35	136.23
300.00	95.57	108.05	77.75	103.23	110.56	169.53	137.17
320.00	97.92	109.46	79.19	105.42	111.73	171.60	138.06
340.00	100.18	110.79	80.58	107.53	112.85	173.56	138.90
360.00	102.35	112.07	81.90	109.55	113.91	175.44	139.69
380.00	104.45	113.28	83.18	111.50	114.92	177.23	140.45
400.00	106.48	114.45	84.41	113.39	115.89	178.95	141.17
420.00	108.45	115.58	85.59	115.21	116.83	180.59	141.86
440.00	110.37	116.66	86.74	116.97	117.72	182.18	142.52
460.00	112.23	117.70	87.85	118.68	118.59	183.71	143.16
480.00	114.03	118.70	88.92	120.34	119.42	185.18	143.77
500.00	115.80	119.68	89.96	121.95	120.23	186.61	144.36

Figure E-3. Wind Pressure and Wind Velocity for 110 mph at 33 ft

WIND LOADING PRESSURE ANALYSIS FOR A STEADY-STATE WIND = 115.00 MPH AT 30 FEET
EXPOSURE D, CATAGORY III BUILDING

HEIGHT, Z (ft)	ASCE Paper No. 3269 Steady-state Total Pressure (psf)	ANSI A58.1-1982 Steady-state Total Pressure (psf)	Standard Building Code Steady-state Total Pressure (psf)	ASCE Paper No. 3269 Peak Total Pressure (psf)	ANSI A58.1-1982 Peak Total Pressure (psf)	ASCE Paper No. 3269 Velocity Profile (mph)	ANSI A58.1-1982 Velocity Profile (mph)
30.00	43.98	74.52	44.01	53.21	83.44	115.00	113.91
33.00	45.48	75.95	45.23	54.77	84.71	116.95	115.00
40.00	48.68	78.93	47.78	58.04	87.33	120.99	117.23
60.00	56.18	85.60	53.65	65.59	93.16	129.98	122.08
80.00	62.19	90.67	58.25	71.54	97.55	136.75	125.65
100.00	67.29	94.80	62.08	76.52	101.11	142.25	128.48
120.00	71.77	98.32	65.40	80.85	104.12	146.91	130.85
140.00	75.79	101.40	68.35	84.70	106.75	150.96	132.88
160.00	79.45	104.15	71.01	88.18	109.08	154.57	134.67
180.00	82.82	106.63	73.44	91.37	111.19	157.82	136.26
200.00	85.96	108.90	75.68	94.32	113.11	160.78	137.70
220.00	88.91	111.00	77.77	97.07	114.87	163.51	139.02
240.00	91.68	112.95	79.73	99.65	116.51	166.04	140.24
260.00	94.31	114.77	81.57	102.09	118.05	168.41	141.37
280.00	96.81	116.48	83.32	104.40	119.48	170.63	142.42
300.00	99.20	118.10	84.98	106.59	120.84	172.72	143.40
320.00	101.49	119.63	86.56	108.69	122.12	174.70	144.33
340.00	103.69	121.09	88.07	110.69	123.34	176.58	145.21
360.00	105.80	122.49	89.52	112.62	124.50	178.37	146.04
380.00	107.84	123.82	90.91	114.47	125.61	180.08	146.83
400.00	109.82	125.09	92.26	116.26	126.67	181.72	147.59
420.00	111.72	126.32	93.55	117.98	127.69	183.30	148.31
440.00	113.58	127.50	94.80	119.65	128.67	184.81	149.00
460.00	115.37	128.64	96.01	121.26	129.61	186.27	149.67
480.00	117.12	129.74	97.19	122.83	130.52	187.67	150.30
500.00	118.82	130.80	98.33	124.35	131.40	189.03	150.92

Figure E-4. Wind Pressure and Wind Velocity for 115 mph at 33 ft

WIND LOADING PRESSURE ANALYSIS FOR A STEADY-STATE WIND = 120.00 MPH AT 30 FEET
EXPOSURE D, CATAGORY III BUILDING

HEIGHT, Z (ft)	ASCE Paper No. 3269 Steady-state Total Pressure (psf)	ANSI A58.1-1982 Steady-state Total Pressure (psf)	Standard Building Code Steady-state Total Pressure (psf)	ASCE Paper No. 3269 Peak Total Pressure (psf)	ANSI A58.1-1982 Peak Total Pressure (psf)	ASCE Paper No. 3269 Velocity Profile (mph)	ANSI A58.1-1982 Velocity Profile (mph)
30.00	47.89	81.14	47.92	57.94	90.86	120.00	118.86
33.00	49.42	82.70	49.25	59.49	92.24	121.91	120.00
40.00	52.67	85.94	52.03	62.75	95.09	125.85	122.33
60.00	60.23	93.20	58.42	70.21	101.44	134.58	127.39
80.00	66.24	98.72	63.42	76.03	106.22	141.14	131.11
100.00	71.32	103.23	67.60	80.88	110.09	146.45	134.07
120.00	75.75	107.06	71.21	85.07	113.38	150.93	136.54
140.00	79.72	110.41	74.42	88.78	116.24	154.83	138.66
160.00	83.32	113.40	77.31	92.13	118.78	158.29	140.52
180.00	86.63	116.10	79.96	95.18	121.07	161.40	142.19
200.00	89.70	118.58	82.40	98.00	123.16	164.24	143.69
220.00	92.58	120.86	84.68	100.62	125.08	166.85	145.07
240.00	95.28	122.98	86.81	103.08	126.87	169.27	146.34
260.00	97.84	124.96	88.82	105.39	128.53	171.53	147.51
280.00	100.27	126.83	90.72	107.58	130.10	173.64	148.61
300.00	102.58	128.59	92.53	109.65	131.57	175.63	149.64
320.00	104.79	130.26	94.25	111.63	132.97	177.52	150.61
340.00	106.92	131.85	95.89	113.52	134.30	179.31	151.52
360.00	108.96	133.37	97.47	115.33	135.56	181.01	152.39
380.00	110.93	134.82	98.99	117.07	136.77	182.64	153.22
400.00	112.82	136.21	100.45	118.75	137.92	184.20	154.01
420.00	114.66	137.54	101.86	120.37	139.03	185.69	154.76
440.00	116.44	138.83	103.22	121.93	140.10	187.12	155.48
460.00	118.16	140.07	104.54	123.44	141.13	188.50	156.17
480.00	119.84	141.27	105.82	124.90	142.12	189.84	156.84
500.00	121.47	142.42	107.06	126.32	143.08	191.12	157.48

Figure E-5. Wind Pressure and Wind Velocity for 120 mph at 33 ft

WIND LOADING PRESSURE ANALYSIS FOR A STEADY-STATE WIND = 125.00 MPH AT 30 FEET
EXPOSURE D, CATAGORY III BUILDING

HEIGHT, Z (ft)	ASCE Paper No. 3269 Steady-state Total Pressure (psf)	ANSI A58.1-1982 Steady-state Total Pressure (psf)	Standard Building Code Steady-state Total Pressure (psf)	ASCE Paper No. 3269 Peak Total Pressure (psf)	ANSI A58.1-1982 Peak Total Pressure (psf)	ASCE Paper No. 3269 Velocity Profile (mph)	ANSI A58.1-1982 Velocity Profile (mph)
30.00	51.96	88.04	52.00	62.87	98.59	125.00	123.81
33.00	53.51	89.73	53.44	64.40	100.08	126.85	125.00
40.00	56.78	93.25	56.45	67.60	103.18	130.67	127.43
60.00	64.34	101.13	63.39	74.89	110.06	139.10	132.70
80.00	70.31	107.12	68.82	80.53	115.25	145.41	136.57
100.00	75.32	112.01	73.35	85.19	119.46	150.50	139.66
120.00	79.68	116.17	77.27	89.20	123.02	154.79	142.23
140.00	83.56	119.81	80.75	92.74	126.12	158.52	144.43
160.00	87.07	123.05	83.89	95.92	128.88	161.82	146.38
180.00	90.30	125.98	86.76	98.81	131.37	164.78	148.11
200.00	93.28	128.66	89.41	101.48	133.63	167.48	149.68
220.00	96.06	131.14	91.88	103.95	135.72	169.96	151.11
240.00	98.67	133.44	94.20	106.26	137.66	172.26	152.43
260.00	101.14	135.60	96.37	108.42	139.47	174.40	153.66
280.00	103.48	137.62	98.44	110.47	141.17	176.40	154.80
300.00	105.70	139.53	100.40	112.41	142.77	178.29	155.87
320.00	107.83	141.34	102.26	114.26	144.28	180.07	156.88
340.00	109.86	143.07	104.05	116.02	145.72	181.76	157.84
360.00	111.82	144.71	105.76	117.70	147.09	183.37	158.74
380.00	113.70	146.29	107.41	119.32	148.40	184.91	159.60
400.00	115.51	147.80	109.00	120.87	149.66	186.38	160.42
420.00	117.26	149.24	110.53	122.37	150.86	187.78	161.21
440.00	118.96	150.64	112.01	123.82	152.02	189.14	161.96
460.00	120.60	151.99	113.44	125.21	153.14	190.44	162.68
480.00	122.19	153.28	114.83	126.57	154.21	191.69	163.37
500.00	123.74	154.54	116.17	127.88	155.25	192.90	164.04

Figure E-6. Wind Pressure and Wind Velocity for 125 mph at 33 ft

APPENDIX F

REFERENCE DOCUMENTS

REFERENCE DOCUMENTS

1. ANSI A58.1-1982. "Minimum Design Loads for Buildings and Other Structures." American National Standards Institute, New York, NY.

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15. Supplementary Notes

16. Abstract

The following analysis is a comparison of analytical methods for the calculation of wind load pressures. The analytical methods specified in ASCE Paper No. 3269, ANSI A58.1-1982, the Standard Building Code, and the Uniform Building Code were analyzed using various hurricane speeds to determine the differences in the calculated results. The winds used for the analysis ranged from 100 mph to 125 mph and applied inland from the shoreline of a large open body of water (i.e., a large lake or the ocean) a distance of 1500 feet or ten times the height of the building or structure considered. For a building or structure less than or equal to 250 feet in height acted upon by a wind greater than or equal to 115 mph, it was determined that the method specified in ANSI A58.1-1982 calculated a larger wind load pressure than the other methods. For a building or structure between 250 feet and 500 feet tall acted upon by a wind ranging from 100 mph to 110 mph, there is no clear choice of which method to use; for these cases, factors that must be considered are the steady-state or peak wind velocity, the geographic location, the distance from a large open body of water, and the expected design life and its risk factor.

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